**CRJ-700 Alerting Issues – Stall**

**1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Stall push light switch on glareshield will illuminate | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | None | None | Reduction of AOA |
| | Auto-pilot disconnect cavalry charge will occur with stick shaker activation causing the green "AP" on PFD to change to red then disappear | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | None | None | None, will flash twice then red "AP" will disappear from PFD |
| **Aural Alerts** | Stick shaker | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | None | Reduction of AOA |
| | Stall warbler | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | None | Reduction of AOA |
| | Auto-pilot disconnect cavalry charge will occur with stick shaker activation | Stick shaker | May catch pilots off guard if unaware that the aircraft is very slow | | | none, will sound once and stop |
| **Tactile Alerts** | Stick shaker | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | None | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | Current airspeed into low airspeed cue (i.e. lower checker board) | Current speed at or below lower airspeed cue | | None | None | Reduction of AOA |
| | Current airspeed below "green line" Low Speed Awareness Indicator (i.e.1.25 times $V_{S1}$) | Current speed at or below lower airspeed cue | None | None | None | Reduction of AOA/Thrust increase |
| | Airspeed trend predictor indicating into the checker board | Current aircraft configuration including AOA, thrust and lift device deployment will show the predicted airspeed in 10 seconds | None | None | None | Reduction of AOA/Thrust increase |
| | Cont Ignition on EICAS (white message) | Predetermined angle of attack (AOA) is reached or predicted to be reached. | Could have been selected on for other required reasons | Not easily visible and attention is drawn to other more salient alerts/cues | None | Reduction of AOA |
| | Continuous ignition push/light switch is illuminated on overhead panel | Predetermined angle of attack (AOA) is reached or predicted to be reached. | Could have been selected on for other required reasons | Not easily visible and attention is drawn to other more salient alerts/cues | None | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | PFD/ADI indications of uncommanded pitch | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | | |
| | Roll rate on PFD/EADI | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | Uncommanded roll cues masked by autopilot roll inputs until the a/p disconnects (appears as wheel deflection, see below); however, rapid roll may accompany a/p disconnect at the stall. | |
| | Sink rate on vertical speed display | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | | |
| | Wheel may move opposite the roll if autopilot is engaged. | | | | | |

**CRJ-700 Alerting Issues – Stall**

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Aural Cues** | None | | | | | |
| **Tactile/ Somatic Cues** | Stick pusher | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | None | Reduction of AOA; Turn off STALL PTCT PUSHER switch; Press and hold AP/SP button |
| | Aircraft handles poorly (mushy)/wing drop | Subjective & variable | These cues are not normally presented in training so pilots are more likely to be distracted/derailed by them. | None | None | Unknown, subjective & variable |
| | Airframe buffet | Specific angle of attack (AOA) is reached. | These cues are not normally presented in training so pilots are more likely to be distracted/derailed by them. | Could be confused with high speed buffet; Severe engine or airframe damage could also produce this sensation | | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

**Expected Pilot Response(s)**

(1) Autopilot .....Disengage, if required
(2) Pitch attitude ..... Lower nose to reduce angle of attack
(3) Thrust levers .....Advance to MAX POWER
(4) Roll attitude ..... Wings level
(5) FLIGHT SPOILER lever .....RETRACT

**After airspeed increases and stall warning is extinguished:**

(6) Pitch attitude .....Adjust to minimize altitude loss

**NOTE**

1. It is essential that the AOA be immediately reduced, even if this means a loss of altitude.
2. Avoid abrupt or aggressive pitch control inputs during recovery. Inappropriate recovery inputs can result is a secondary stall.
3. Height loss resulting from high AOA recovery, especially at cruise altitude and/or low initial thrust conditions, can be significant.

**Possible sources of confusion with regard to pilot response(s)**

- Autopilot may trim into low airspeed condition before disconnecting, resulting in nose-up pitch rate and greater need to re-trim during recovery.
- Autopilot may disconnect while holding wheel input, resulting in rapid roll at the time of disconnection.
- High altitude stall may require greater nose-down input than the stalls trained in the simulator.
- High altitude stall may lead to high speed buffet during recovery, with cues similar to low-speed buffet but different recovery actions required.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

**How does pilot know condition is resolved/recovered?**

- Termination of stall warning alerts

**Issues with regard to multiple concurrent non-normal conditions**

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

**CRJ-700 Alerting Issues – Stall**

**2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Stall push light switch on glareshield will illuminate | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | | | Reduction of AOA |
| **Aural Alerts** | Stick shaker | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | | Reduction of AOA |
| | Stall warbler | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Tactile Alerts** | Stick shaker | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | | Reduction of AOA |
| **Visual Cues** | Current airspeed into low airspeed cue (i.e. lower checker board) | Current speed at or below lower airspeed cue | | | | Reduction of AOA |
| | Current airspeed below "green line" Low Speed Awareness Indicator (i.e.1.25 times $V_{S1}$) | Current speed at or below lower airspeed cue | | | | Reduction of AOA/Thrust increase |
| | Airspeed trend predictor indicating into the checker board | Current aircraft configuration including AOA, thrust and lift device deployment will show the predicted airspeed in 10 seconds | | | | Reduction of AOA/Thrust increase |
| | Cont Ignition on EICAS (white message) | Predetermined angle of attack (AOA) is reached or predicted to be reached. | Could have been selected on for other required reasons | Not easily visible and attention is drawn to other more salient alerts/cues | | Reduction of AOA |
| | Continuous ignition push/light switch is illuminated on overhead panel | Predetermined angle of attack (AOA) is reached or predicted to be reached. | Could have been selected on for other required reasons | Not easily visible and attention is drawn to other more salient alerts/cues | | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | PFD/ADI indications of uncommanded pitch | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | | |
| | Roll rate on PFD/EADI | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | Uncommanded roll cues masked by autopilot roll inputs until the a/p disconnects (appears as wheel deflection, see below); however, rapid roll may accompany a/p disconnect at the stall. | |
| | Sink rate on vertical speed display | | Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions. | | | |

**CRJ-700 Alerting Issues – Stall**

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Aural Cue** | Wind noise | | Wind noise is not a reliable cue to angle-of-attack, but loud wind noise may potentially mislead pilots into thinking they are not stalling during a high-speed stall | | | |
| **Tactile/ Somatic Cues** | Stick pusher | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | None | Reduction of AOA; Turn off STALL PTCT PUSHER switch; Press and hold AP/SP button |
| | Aircraft handles poorly (mushy)/wing drop | Subjective & variable | These cues are not normally presented in training so pilots are more likely to be distracted/derailed by them. | | | Unknown, subjective & variable |
| | Airframe buffet | Specific angle of attack (AOA) is reached. | These cues are not normally presented in training so pilots are more likely to be distracted/derailed by them. | Could be confused with high speed buffet or sever engine or airframe damage | | Reduction of AOA |

**CRJ-700 Alerting Issues – Stall**

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

**Expected Pilot Response(s)**

(1) Pitch attitude ..... Lower nose to reduce angle of attack
(2) Thrust levers .....Advance to MAX POWER
(3) Roll attitude ..... Wings level
(4) FLIGHT SPOILER lever .....RETRACT

**After airspeed increases and stall warning is extinguished:**

(5) Pitch attitude .....Adjust to minimize altitude loss

**NOTE**

1. It is essential that the AOA be immediately reduced, even if this means a loss of altitude.
2. Avoid abrupt or aggressive pitch control inputs during recovery. Inappropriate recovery inputs can result is a secondary stall.
3. Height loss resulting from high AOA recovery, especially at cruise altitude and/or low initial thrust conditions, can be significant.

**Possible sources of confusion with regard to pilot response(s)**

- Autopilot may trim into low airspeed condition before disconnecting, resulting in nose-up pitch rate and greater need to re-trim during recovery.
- Autopilot may disconnect while holding wheel input, resulting in rapid roll at the time of disconnection.
- High altitude stall may require greater nose-down input than the stalls trained in the simulator.
- High altitude stall may lead to high speed buffet during recovery, with cues similar to low-speed buffet but different recovery actions required.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.
- If terrain proximity, the pilot may have to pitch down while being presented with a "Pull Up" GPWS warning.

**How does pilot know condition is resolved/recovered?**

- Termination of stall warning alerts

**Issues with regard to multiple concurrent non-normal conditions**

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

**CRJ-700 Alerting Issues – Stall**

**3. Initiating Condition: Wing ice accumulation**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | None | | The expected alerts and cues will be absent | Pilots are trained extensively to associate stick shaker as trigger to stall recovery; in absence of stick shaker (warning system failure or stall at lower-than-nominal AOA) they may not interpret the secondary cues of buffet, roll, etc. as being related to stall. | Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA | |
| **Aural Alerts** | None | | | | | |
| **Tactile Alerts** | None: airspeed appears to be adequate but is not; airplane may stall while indicated airspeed is in the amber band but not in or touching the red/black band | | The expected alerts and cues will be absent | Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA | |

**CRJ-700 Alerting Issues – Stall**

3. Initiating Condition: Wing ice accumulation – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Cues** | PFD/ADI indications of uncommanded pitch | | In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall | Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | | |
| | Roll rate on PFD/EADI | | In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall | Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | | |
| | Sink rate on vertical speed display | | In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall | Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | | |
| **Aural Cues** | None | | | | | |

**CRJ-700 Alerting Issues – Stall**

3. Initiating Condition: Wing ice accumulation – Cont.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Tactile/ Somatic Cues** | Unusual wheel/column forces | | Changes in the required control forces from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues). | Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | | |
| | Aerodynamic buffet | AOA (natural) | Buffet cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues). Also, may be confused with high speed buffet. | Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset. | | |

**Expected Pilot Response(s)**

(1) Autopilot .....Disengage, if required
(2) Pitch attitude ..... Lower nose to reduce angle of attack
(3) Thrust levers .....Advance to MAX POWER
(4) Roll attitude ..... Wings level
(5) FLIGHT SPOILER lever .....RETRACT

**After airspeed increases and stall is avoided or recovered:**

(6) Pitch attitude .....Adjust to minimize altitude loss

**NOTE**

1. It is essential that the AOA be immediately reduced, even if this means a loss of altitude.
2. Avoid abrupt or aggressive pitch control inputs during recovery. Inappropriate recovery inputs can result is a secondary stall.
3. Altitude loss resulting from high AOA recovery, especially at cruise altitude and/or low initial thrust conditions, can be significant.

**Possible sources of confusion with regard to pilot response(s)**

- In the absence of the usual salient alerts, the pilots may not realize that the aircraft is stalled.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

**CRJ-700 Alerting Issues – Stall**

3. Initiating Condition: Wing ice accumulation – Cont.

**How does pilot know condition is resolved/recovered?**

- Difficult to know, related to cessation of uncommanded pitch/roll/sink

**Issues with regard to multiple concurrent non-normal conditions**

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

**CRJ-700 Alerting Issues – Stall**

**4. Initiating Condition: False stall warning during takeoff rotation**

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Visual Alerts** | Stall push light switch on glareshield will illuminate | Predetermined angle of attack (AOA) is reached or predicted to be reached. | Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored. | None | None | Reduction of AOA |
| **Aural Alerts** | Stick shaker, sound of (false indication) | AOA | Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored. | | Inhibited on the ground, so the false alert begins during rotation when the aircraft becomes airborne | Alert or cue is not terminated as it is invalid |
| | Stall warbler | Predetermined angle of attack (AOA) is reached or predicted to be reached. | | Could be a malfunctioning stall protection system | Inhibited on the ground, so the false alert begins during rotation when the aircraft becomes airborne | Reduction of AOA |
| **Tactile Alerts** | Stick shaker (false indication) | AOA | Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored. | | Inhibited on the ground, so the false alert begins during rotation when the aircraft becomes airborne | Alert or cue is not terminated as it is invalid |
| **Visual Cues** | Normal vertical speed, altimeter, and airspeed indications on PFD, as well as view through the windshield of the aircraft climbing (if VMC) are subtle cues that the aircraft is not stalling | | Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored. | | | |

**CRJ-700 Alerting Issues – Stall**

4. Initiating Condition: False stall warning during takeoff rotation – Cont.

| Type | Alert or cue | Threshold for alert or cue to be presented | Confusion regarding alert or cue | Other issues with regard to alert or cue | When alert is inhibited/ suppressed or when cue is masked | How alert or cue is terminated |
|---|---|---|---|---|---|---|
| **Aural Cues** | None | | | | | |
| **Tactile/ Somatic Cues** | Normal vertical acceleration from rotation into climb is a subtle cue that the aircraft is not stalling | | Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored. | | | |

**Expected Pilot Response(s)**

- Ignore false alerts and cues.
- Do not reject takeoff.

**Possible sources of confusion with regard to pilot response(s)**

- Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.
- Pilots are trained to respond to stall warnings/alerts immediately and without deliberation, decreasing the likelihood of identifying the false warning through effortful analysis and suppressing the reaction to the false warning.
- Split-second decision to perform a late rejection or continue.

**How does pilot know condition is resolved/recovered?**

- Observe normal takeoff and climb performance.

**Issues with regard to multiple concurrent non-normal conditions**

- None unless pilot takes unneeded actions, such as high speed RTO.